CHAPTER 19: BOILER PURGE (Blowdown)

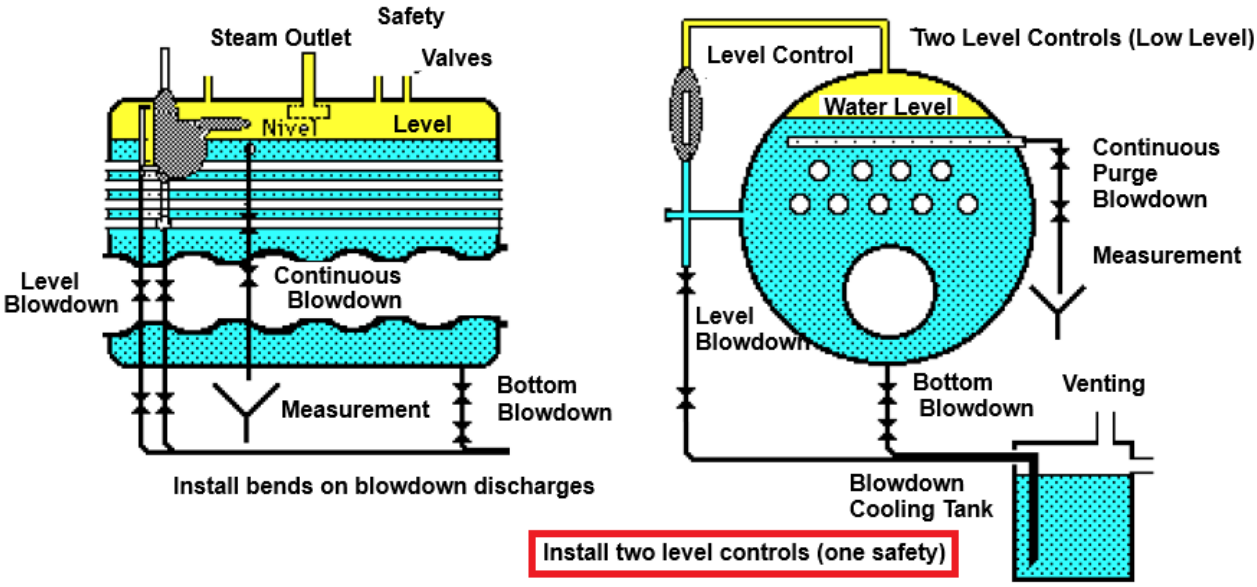
Purging the boiler level is mandatory for safety reasons (every 4 hours). It removes any sludge that may have accumulated in the boiler chamber and very little water, given the short extraction time.

However, it is crucial to verify that the burner shuts off during purging.

In some plants, this affects the timing of purging. To avoid shutting down the boiler, **in some cases it can be so critical that a device is needed to test the level control.**

This device does not allow the boiler to be shut down if a **temporary override button is pressed**, but it does allow the system to be tested.

Extreme caution must be exercised when implementing this type of system. There must be no possibility of the burner shutdown system being permanently disabled, even due to a system failure.



Bottom blowdowns cannot always be performed at any time (never in manifolds, gas generators, etc., with the burner lit, as this could interrupt internal circulation and burn the manifold or gas generator).

In the boiler body, it depends on the pressure, the diameter of the blowdown, the type of boiler, etc.

However, it is always advisable to perform bottom blowdown with the burner off and, if possible, with the steam outlet closed.

In low-pressure boilers (10 kg/cm² - 142 PSI), perform short, repeated <u>blowdowns at full pressure</u>, allowing sludge to accumulate at the purge blowdown outlet.

In high-pressure boilers, do not perform blowdown at full pressure, as the purpose of bottom blowdown is to remove sludge (which should settle to the bottom of the boiler) and salts.

The bottom blowdown should have two valves: a safety valve (close to the boiler) and an operating valve for the blowdown.

Open the safety valve fully, then gently blow down the boiler with the operating valve to heat the pipes without risk of breakage. Open the operating valve fully, then close the safety valve after the blowdown is complete, and finally close the safety valve (close to the boiler).

This valve allows for the repair of the operating blowdown valve—which suffers significant wear on its seat due to sludge—in case it becomes damaged while the boiler is running or even gets stuck open.

It also prevents leaks, which result in continuous, unwanted blowdown.

Both valves should be almost full-flow and appropriate according to the standards for their intended function.

Serious accidents can occur when operating the blowdown system if the valves are not suitable, the pipes are not properly installed and secured, and the operation is not performed correctly.

Heat the system gently, opening the operating valve fully, but without causing a shock or water hammer.

Sometimes the mistake is made of installing blowdown valves with very long pipes, seeking the "convenience" of the boiler operator or a supposed "safety."

This is not advisable, since when the blowdown valves are opened, the water inside the pipe accumulates a great deal of "kinetic energy" (1/2 mv², an equation that gives the amount of energy developed, indicating that half the "mass" times the square of the water's velocity becomes dynamic energy).

Because blowdown valves can be closed "quickly," when the water flow is cut off, the mass of water that accumulated this energy develops pressure on the valve and the pipe closest to it. The pressure depends on how quickly the valve closes, resulting in a very high pressure (called "water hammer").

This pressure can cause the valve body or the pipe to burst (this pressure is added to the existing pressure). the boiler has, minus the pressure loss due to pipe friction and something that comes from the elastic expansion of the pipe).

We can say that a blowdown valve operating on a boiler at 15 kg/cm², if it has a pipe approximately 15 meters long and with a 2-inch diameter, can quadruple the pressure.

This pressure, known as "water hammer," often occurs nowadays due to the presence of "ball" valves (most of which are full-flow and quick-operating).

Many water softener bodies, in which these valves are installed, can, when closed rapidly, "increase the internal pressure of the softener," causing the softener body to crack or even explode (especially when made of resins or plastic).

For example, a softener operating at a water pressure of 3 kg/cm² at the end of a long pipe can increase this pressure to more than 15 kg/cm².

To understand this problem with purge blowdown valves, we can imagine that "water hammer" is like "a hammer striking an anvil"—that is, suddenly stopping a mass moving at high speed, like a driver crashing into a wall.

I have witnessed several accidents caused by this type of error throughout my long career in this field. Blowdown valves must be placed as close as possible to the boiler body connection, or serious risks are involved.

The bottom purge blowdown valve must withstand:

1- High mechanical stress (pressure and erosion)

2- A significant thermal shock

3- Full flow (suspended solids)

4- Plated or welded for medium and high pressure applications

5- Double valves are recommended (for greater safety)

6- Pipes securely attached to the structure (allowing for expansion)

7- Adequate capacity for the function

8- Blowdown valves should be located as close as possible to the boiler body connection to prevent "water hammer".

Continuous blowdown is responsible for removing dissolved salts (it has the advantage of being able to run continuously, not affecting production, and being very easy to regulate, etc.).

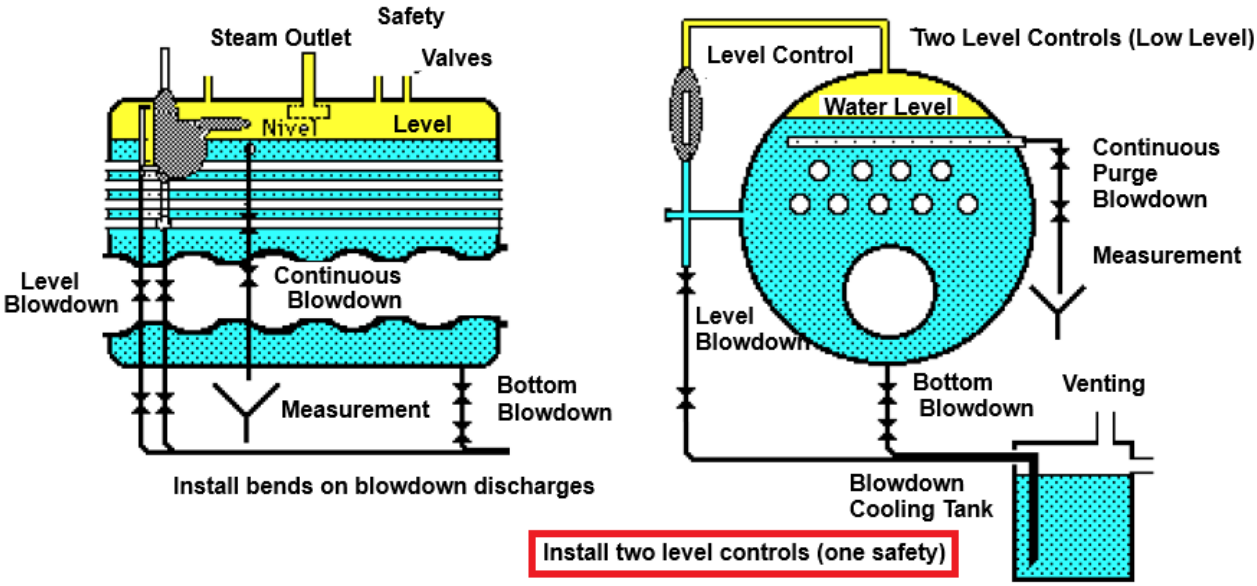
It is advisable that the continuous blowdown system have its own independent discharge (heat can be recovered in a heat exchanger), allowing for visual monitoring and the ability to volumetrically measure the volume of water being discharged per minute.

However, calculating the total purge percentage is crucial, as it allows you to determine the liters per minute of continuous purge. Plus water purge lost in level purges—approximately 20-40 L per level—and bottom purges, which vary but generally do not exceed 80-150 L per normal bottom purge.

TOTAL PURGE = BLOWDOWNS AT EACH LEVEL + BOTTOM + CONTINOUS

This value can be calculated by determining the water surface area in dm² and multiplying it by the level drop in dm after the blowdown, assuming the feed pump has not started.

Example:
A 2000 kg/hr fire-tube steam boiler with a water surface area of 25 dm x 12 dm = 300 dm², the level drops 0.2 dm, or 2 cm, so the "blowdown" water is 300 dm² x 0.2 dm = 60 L per blowdown. As you can see, not much water is removed by the blowdown.



It is advisable that the continuous purge blowdown system have two valves: one against the boiler for complete opening and closing (start and end of the workday), and another valve (further out) to regulate the flow rate of water to be purged.

This second valve should have a suitable, hard seat, such as chrome-nickel, with a needle-type closure or similar, regulating a small flow rate, which generally varies between 0.3 L/min and 30 L/min.

The continuous blowdown should be regulated according to the pH, TDS, or other established maximum limits.

Let's look at the calculation under different circumstances.

When there is an excessive and uncontrollable purge, the cause should be investigated as water leaks from the purge valves (check if the pipe is hot, approximately 1 meter from the last valve; if so, it is clear that water is being lost).

When there is a lack of purge, it is clear that for some reason more water with salts than normal is being added (here the problem could be due to: loss of condensate that was being recovered, a change in water quality, such as the introduction of well water instead of surface water, generally potable water, etc.).

But it could also be that for some reason the flow rate of the bottom or continuous purge is lower than it was, due to an obstruction.

In the case of continuous purge, measuring the volume of water per minute is very important.

At the bottom valve, you should observe how much the visual water level drops, since the purge makes "a lot of noise" due to the "flash," but its volume may have decreased due to an obstruction.

Calculating the Purge Blowdown Percentage:

Since the water replenished in a boiler contains a certain amount of salts, and other salts are added (chemical treatment), it is important to establish a blowdown schedule to remove the excess salts accumulated in the boiler water (the limit will be set by the maximum permissible total dissolved salts or by some of the limiting factors: pH, alkalinity, chlorides, silica, etc.).

Purge blowdown procedures include both bottom blowdowns (which remove sludge and dissolved salts) and continuous blowdowns (which are used to maintain the maximum dissolved salt limit).

Every 4 hours level blowdowns (a minimum of two switches, one for operation and a second for safety) are performed to verify the burner shutdown.

The blowdown percentage can be calculated or measured based on the makeup water in different ways:

1- Considering chlorides (chloride ion).

Since chlorides in water are difficult to precipitate, by measuring the chlorides in the makeup water and the boiler water, we can establish:

Cl a.c. (chlorides in the boiler water),
Cl a.r. (chlorides in the makeup water = condensate + makeup water).
We measure in ppm as chloride ion (Cl-).

Cl a.c. ÷ Cl a.r. = Cycles of Concentration

Cycles of concentration are equal to the number of times the makeup water has been concentrated.

Simple example: if we evaporate 1 liter of water down to half a liter, the concentration of all the salts will double. That is, if the chlorides were at 20 ppm, they will become 40 ppm.

So in this example; 40 ÷ 20 = 2 cycles of concentration.

In the boiler, the total amount of water remains the same, but the salts become more concentrated as the incoming water evaporates.

The blowdown percentage on makeup water will be:

(1 ÷ concentration cycles) x 100 = % Blowdown on makeup water

Example:
Boiler water with chlorides at Cl (boiler water) = 200 ppm
Makeup water from OSE (the company that supplies drinking water in Uruguay) at Cl (makeup water) = 20 ppm

We will have 200 ÷ 20 = 10 concentration cycles and the blowdown percentage on makeup water is (1 ÷ 10) x 100 = 10% blowdown.

This means that 10% of the water that must be added is removed through blowdown or losses in the blowdown valves (as boiler water).

This method measures the amount of blowdown, but does not define it

.

2- If we wanted to establish the approximate percentage of blowdown based on TSD,
we would perform the following calculation:

Maximum total dissolved solids in the boiler (Max. TSD).....ppm.
Total dissolved solids in the makeup water (Rep. TSD).....ppm.
Total chemical treatment per m^3 of makeup water (g/m^3) of salts.

Cycles of concentration = Max. TSD ÷ (Rep. TSD + Treatment g/m^3)

The inverse of the cycles of concentration multiplied by 100 will give the approximate percentage of blowdown on makeup water (since some salts will tend to decompose).

Example:
Maximum limit of total dissolved salts in the boiler at 10 kg/cm^2 (142 PSI pressure):
-Max. TDS = 3000 ppm,
-Softened OSE water with the same TDS = 240 ppm,
-150 grams/m^3 of chemicals (polyphosphates, sulfites, etc.) are added per cubic meter of water.

Approximate concentration cycles = 3000 ÷ (240 + 150) = 7.7 cycles
Blowdown percentage = (1 ÷ 7.7) x 100 = Approx. 13%

This means that we must "blow" approximately 13% of the softened water we add.

That is, if the boiler consumes 2000 liters... For every hour of softened O.S.E. water, ***we must purge 2000 x 13÷100 = 260 Liters per hour****.*

Since the amount of water lost through bottom and level blowdowns is relatively small, we must use continuous blowdown because:

One bottom blowdown releases approximately 50 to 100 liters per session.

One level blowdown (2 levels) releases 20 to 40 liters per session.

If the boiler is blown 3 times per shift (8 hours), this means, taking the higher values (100 + 40) x 3 = 420 liters.

However, since we must blow down the boiler per shift: 260 liters/hour x 8 = 2080 liters.

The difference is 2080 - 420 = ***1660 liters that still need to be blown****.*

Either we do many bottom purges (which is not practical and the heat cannot be recovered) or we establish a continuous (surface) purge, which will "pull" per minute: 1660 /(8 x 60) = ***3.4 Ltrs./ minute****. (we can measure it with a jug if we recover the heat; after cooling there will be no flash steam).*

Calculation of feedwater consumption:
1st case, without condensate return.

Given a heavy fuel oil boiler that consumes 500 liters of fuel oil per day for 10 hours of operation. The pressure is 10 kg/cm² (142 PSI) of saturated steam, and the feedwater at 20°C (68°F) is without condensate return (O.S.E. Montevideo, softened, with 240 ppm TSD and a chemical treatment of 150 g/m³, previous example).

The boiler operates at 50% of its nominal capacity. Its efficiency at LHV without blowdown (100% condensate return, obviously not realistic) is estimated to be 82%, and then with blowdown and no condensate return, 79%.

Let's calculate, taking the values from the previous tables approximately:

1-Without purging (100% condensate return, an ideal case)

Heat required to vaporize 1 kg of water (664 - 20) = 644 kcal/kg of steam.

Available heat per kg of fuel oil: 9700 x 82 ÷ 100 = 7,954 kcal/kg. Steam yield per kg of fuel oil without purging: 7,954 ÷ 644 = 12.35 kg/kg.
Purge is always necessary for safety (levels, bottom, etc.).

Since fuel oil weighs less than water, we consider 1 liter of fuel oil to be 0.960 kg.
Therefore, 500 liters... The amount of fuel oil will be 500 x 0.960 = 480 kg in 10 hours.
The amount of steam per hour will be 480 x 12.35 ÷ 10 = 593 kg/h of steam.

Without blowdown, we should feed 593 liters of makeup water per hour.

2-Without return condensate (a real case):

The blowdown will be: C.c. = 3000 ÷ (240+150) = 7.7 cycles, which will give a blowdown percentage of approximately (1÷7.7) x 100 = 13%.

This means that we must blow down approximately 1 x 13 ÷ 100 = 0.130 liters for each liter of feedwater.

To calculate the evaporated water, we use = (9700 x 79) ÷ (644 x 100) = 11.9 kg/kg of fuel oil.

Feedwater = steam + blowdown = steam + feedwater x 1 ÷ C.c.

Feedwater = steam ÷ (1-1/C.c.) = 13.67 L per kg of fuel oil.

Since we are flushing hot water at the steam temperature, this heat must be subtracted from the heat supplied by the fuel: 0.130 x (185-20) x 13.67 = 293 kcal/kg of fuel oil.

Recalculating the amount of fuel lost through blowdown due to the absence of condensate: 480 x 293 ÷ 9700 ÷ 79 x 100 = 18.35 kg of fuel oil wasted through blowdown in 500 L of fuel oil used.

Average steam output (kg/hour): 11.9 kg x 480 kg ÷ 10 h = 571.2 kg/hour.

As condensate return increases, water replenishment decreases, and steam production per kg of fuel increases.

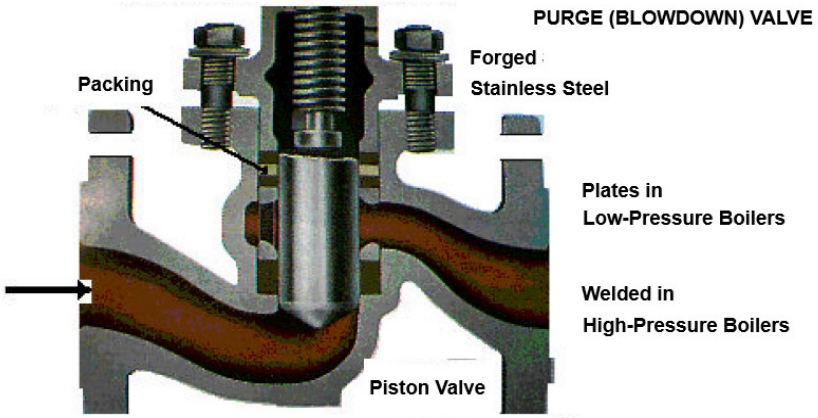
The hourly feed without condensate return will be 13.67 x 480 ÷ 10 = 656 liters of water per hour (approximately).

The total water to be purged without condensate return in 10 hours will be (13.67 - 11.9) x 480 = 849.6 liters.

When there is a percentage of return condensate: Feed Water = Steam x % Cond + Make-up
Feed Water = Steam x % Condensate ÷ 100 x [1 + 1 ÷ (1 - 1 ÷ C.c.)]
50% condensate, with previous salt values and an efficiency of 79.5% L.C.I.
Water evaporated = 9700 x 79.5 ÷ 644 ÷ 100 = 11.97 Kg/Kg of F.Oil
Feed Water = 11.97 x 50 ÷ 100 x [1 + 1 ÷ (1 - 1 ÷ 7.7)] = 12.86 L/kg of fuel oil

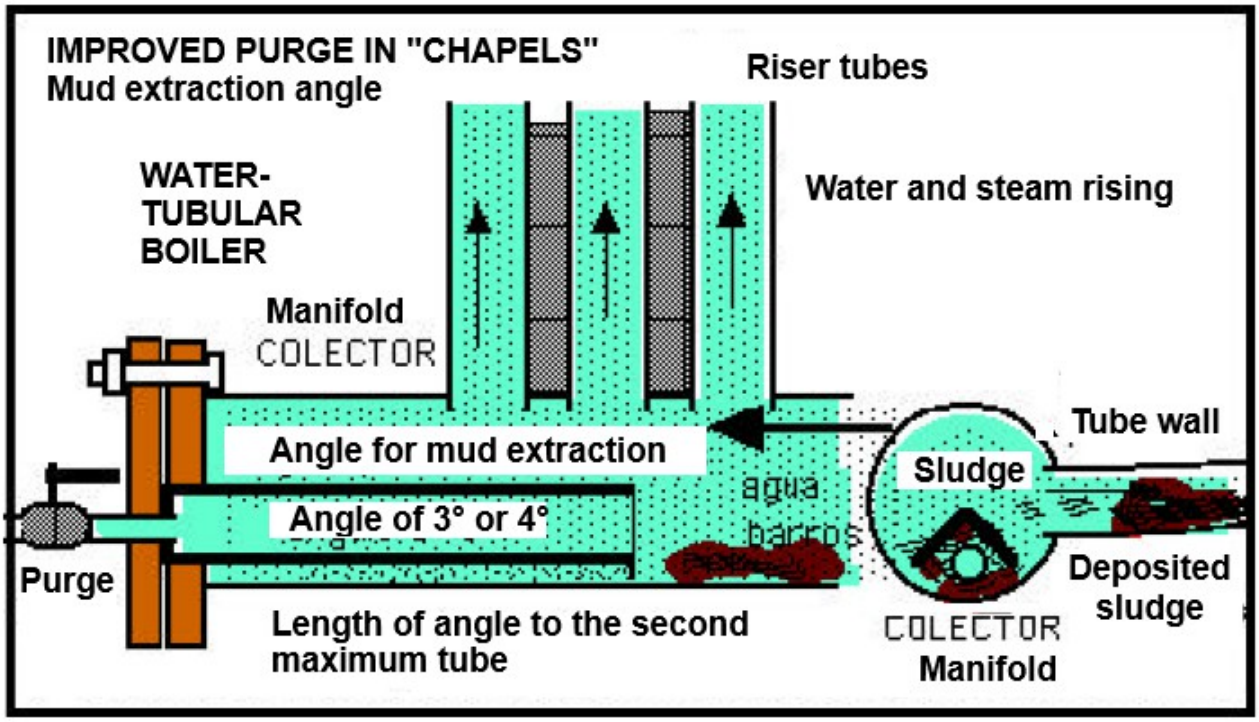
Total water to be purged in 10 hours (12.86 - 11.97) x 480 = 427.2 L

As you can see: greater condensate recovery means less purging, greater performance (efficiency).



“CHAPEL” CHAMBERS (COLLECTORS) PURGE

The "chapels," both the water-tube combustion chambers in "direct-fired" boilers and the water-tube "rear chapels" of "semi-wet bottoms," when there is no "external" chemical treatment to soften the water (water softener, reverse osmosis, or chemical precipitation softening), that is, to remove calcium and magnesium salts or transform them into sodium salts, the "internal" chemical treatments cause the precipitation of scale-forming salts as "removable sludge" through the purges.



IMPROVED PURGE IN "CHAPELS" Sludge extraction angle

When sludge forms inside the boiler, the bottom and header blowdowns must be able to remove it. Therefore, blowdowns must be installed in strategic locations, both at the bottom of the casings and in the headers.

When there are "chapels" (sludge chambers), if these lack blowdowns, sludge will accumulate in the side pipes and the headers themselves.

Even with blowdowns, if they are not of sufficient diameter and do not have an adequate slope, sludge will accumulate in the side pipes and in the headers. Angles (3" to 4", tapped on the flange, leaving a 10 mm gap from the bottom of the header) create a suction effect from the bottom of the header.

This boiler model generally does not have this angle, but it is advisable to install it, especially if it lacks blowdowns.

The purging of the collectors of water-tube boilers must always be done with combustion at minimum or turned off (purge once per shift if there is sludge formation).

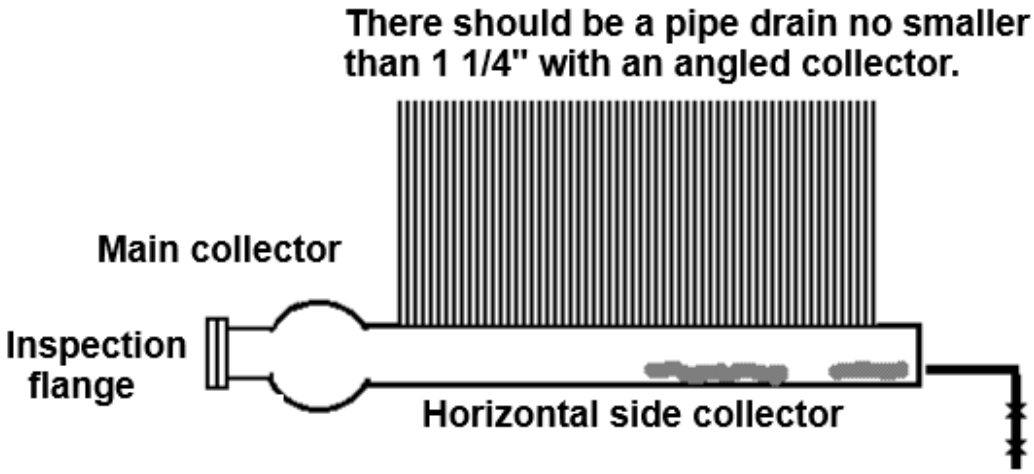
This white paper is not part of original “Pequeño Manual del Foguista 2011”, but was an interesting finding in Apple Macintosh Hard Disc CWT computer;

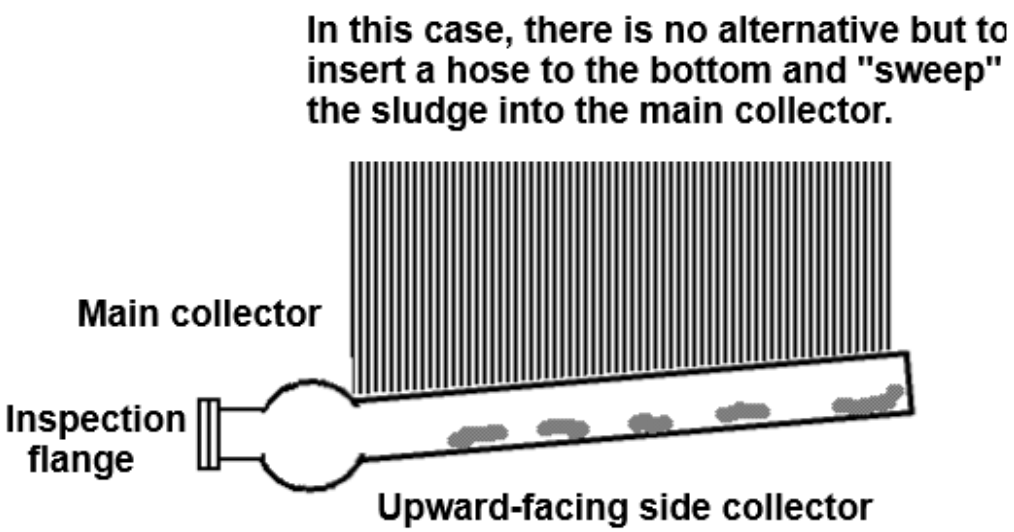
LOW SLUDGE COLLECTORS

Nothing is as important in a boiler as proper internal circulation.
In every horizontal collector, a blowdown should be located at the end of the flow if there is no outlet for the sludge unavoidable in the treatment process, especially the hulls.

When the collector is horizontal, adding a blowdown at the end is not a problem, and it should be able to remove the sludge.

The problem arises when these collectors are improperly designed with an upward slope. In these cases, the blowdown is ineffective, so the boiler must be opened periodically (depending on local conditions) and manually cleaned.





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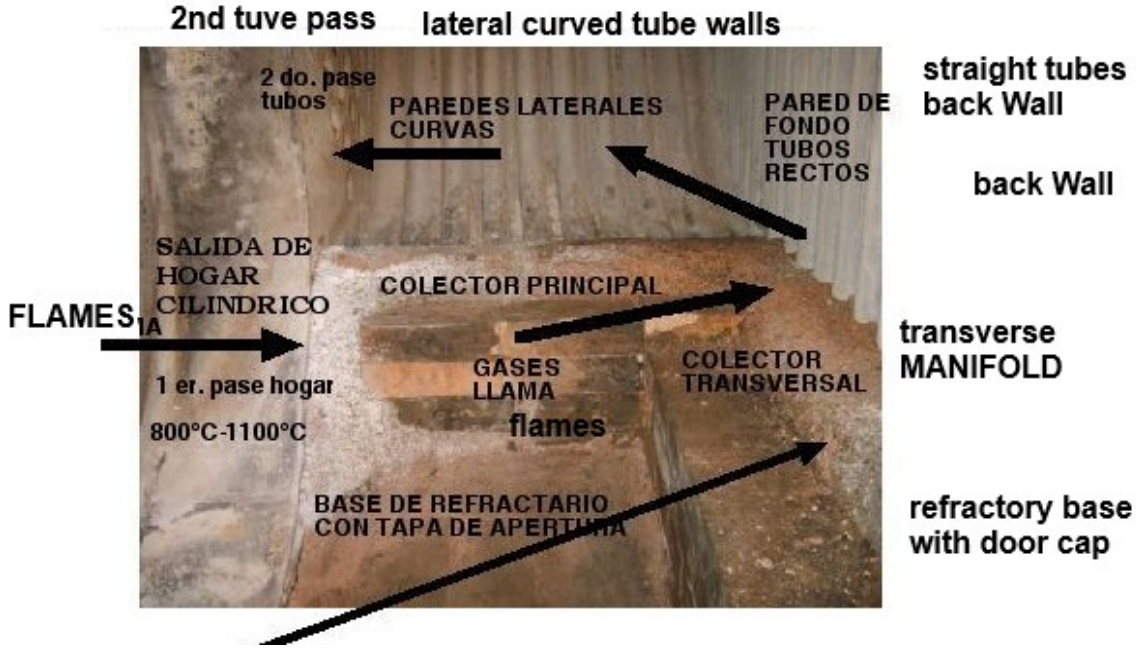
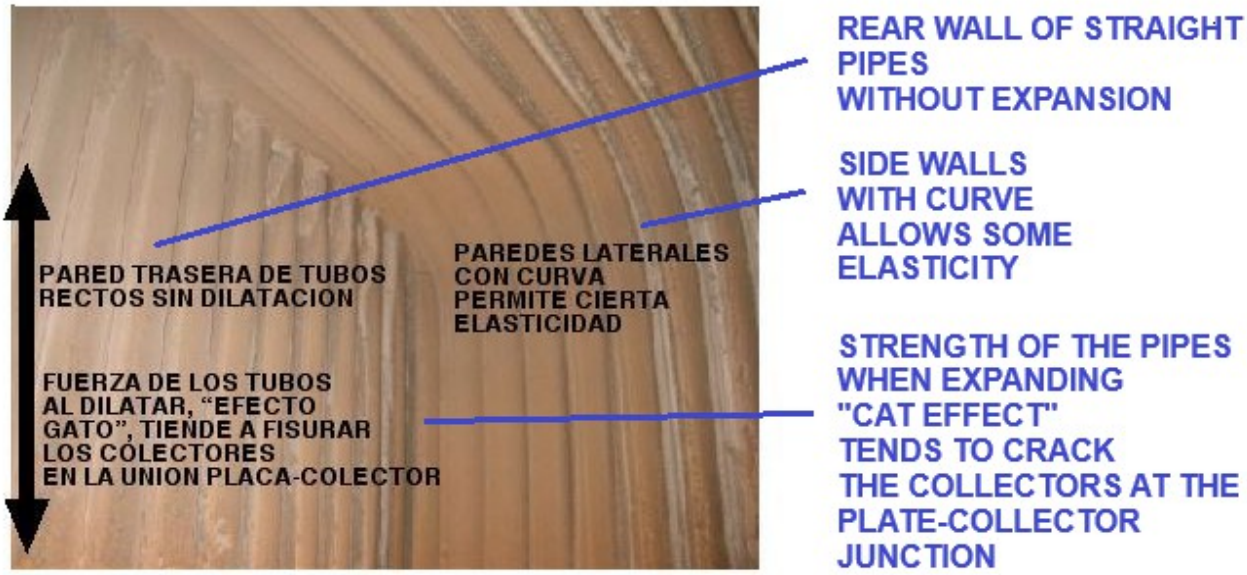
CRACKING PROBLEMS IN REAR CHAPEL COLLECTORS
REAR CHAPEL LAYOUT OF A WOOD-FIRED BOILER (by C.W.T.)

Layout of the tubes in a rear chapel of a wood-fired boiler, showing the curved side walls (which allow for some elasticity) and the straight rear tube wall (which does not allow for elasticity and can cause expansion that creates a "cat effect" on the root of the main collectors, causing them to crack flush with the plate).



The "transverse" collector with the rear wall of the tubes allows the accumulation of sludge that does not exit through the collector purges, hindering internal circulation in the rear wall and increasing the temperature of the straight tubes that expand, "pushing" the collectors towards the crack.



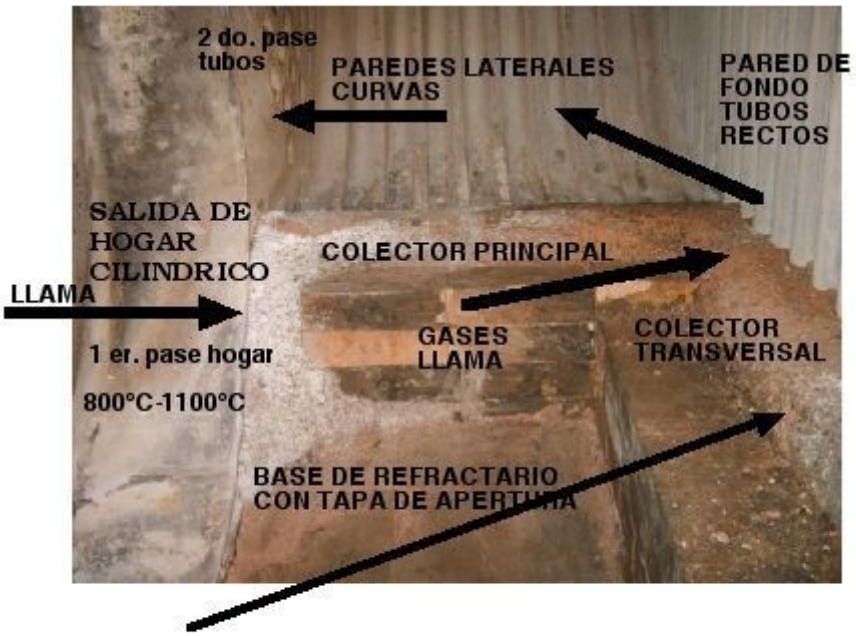
Original White Paper in spanish;

PROBLEMAS DE FISURAS EN COLECTORES CAPILLAS TRASERAS

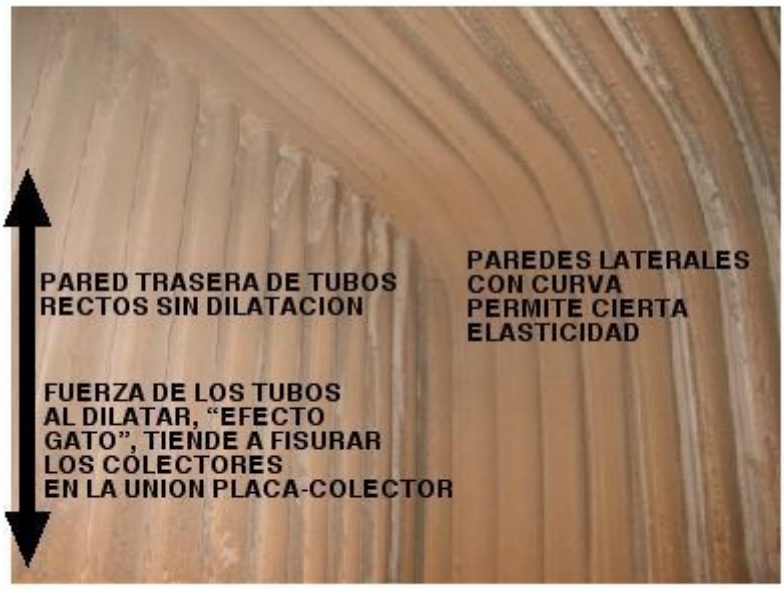
DISPOSICION DE CAPILLA TRASERA DE CALDERA LEÑA

CARLOS W. THOMASSET

Disposición de los tubos de una capilla trasera de caldera a leña, que muestra las paredes laterales curvas (admiten cierta elasticidad) y la pared trasera de tubos recto (que no admite elasticidad y puede provocar dilataciones que provocan un "efecto gato" sobre la raíz de los colectores principales, provocando la fisura de los mismo al raz de la placa.



COLECTOR "TRANSVERSAL" DE PARED DE TUBOS TRASERA PERMITE ACUMULACION DE BARROS QUE NO SALEN POR LAS PURGAS DE LOS COLECTORES, DIFICULTANDO LA CIRCULACION INTERNA DE LA PARED TRASERA Y AUMENTANDO LA TEMPERATURA DE LOS TUBOS RECTOS QUE DILATAN "EMPUJANDO" LOS COLECTORES A LA FISURA.



1996 Photo with C.W.T., our beloved father, a role model to follow. An open book of life, sharing knowledge and experience, something very delicate when dealing with steam boilers, elements with a high risk of fatal accidents. He revealed "unpleasant" experiences that often generated conflicts of interest with boiler manufacturers, industrial plant owners, plant engineers, and accountants who wanted to save money by endangering the lives of boiler operators. But he always had a clear conscience, knowing that nothing was hidden, submitting the corresponding corrective reports to the engineer, the employer, the owner, and the national authorities, in defense of the lives of boiler operators. In Uruguay, there is no union or association of boiler operators, and this lack partly motivated their actions and the writing of this series of books, "The Little Manual for the Boiler Operator," which allowed CWT to influence manufacturers, the purchase and sale of safe new boilers and the dismantling of unsafe boilers as scrap metal, and most importantly, to influence national regulations in Uruguay and the boiler training curriculum at UTU Buceo, the Navy, the Fire Department, and COCAP. Life's paths took us away from the boiler subject (in our case, his son P.J.T.T.) we specialized in hydroelectric power plants, but we were strongly influenced by CWT's human teaching of "not hiding anything", and publishing all knowledge in a formalized manner in technical reports, ranges and maintenance instructions for plant personnel.

Stoker Boiler Handbook 2011, C.W.T. – CHAPTER 19: PURGES (Blowdown)

Fotografía año 1996 con C.W.T., nuestro querido padre, un ejemplo de vida a seguir. Un libro abierto de vida, compartiendo conocimientos y experiencias, algo muy delicado al tratar con calderas de vapor, elementos con alto riesgo de accidentes fatales. Revelación de experiencias "desagradables" que a menudo generaban conflictos de intereses con fabricantes de calderas, propietarios de plantas industriales, ingenieros de planta y contadores que querían ahorrar dinero poniendo en riesgo la vida de los operadores de calderas. Pero siempre con la conciencia tranquila, sabiendo que nada se ocultaba, presentando los informes correctivos correspondientes al ingeniero, al empleador, al propietario y a las autoridades nacionales, en defensa de la vida de los operadores de calderas. En Uruguay, no existe un sindicato ni asociación de operadores de calderas, y esta falta motivó en parte sus acciones y la redacción de esta serie de libros, "El Pequeño Manual del Operador de Calderas", lo que permitió a CWT influir en los fabricantes, en la compra y venta de calderas nuevas seguras y en el desmantelamiento de calderas inseguras como chatarra, y lo mas importante lograr incidir en las reglamentaciones nacionales de Uruguay y la curricula de la capacitación de calderas en UTU Buceo, en la Armada, en Bomberos, y en COCAP. Los caminos de la vida nos alejo del tema calderas (nuestro caso su hijo P.J.T.T.) nos especialiamos en centrales hidroelectricas, pero nos prendio fuerte la humana enseñanza de CWT de "no esconder nada", y publicar protocolizado todo conocimiento en; informes tecnicos, en gamas e instrucciones de mantenimiento para el personal de planta.